

FIRE RISK ASSESSMENT METHOD: GUIDE TO THE RISK METHODOLOGY SOFTWARE

NEW NIST PUBLICATION

December 1990

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Fire Risk Assessment Method: Guide to the Risk Methodology Software

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This guide provides the background on the computer programs used in the Risk Assessment Method. The program modules are tabulated and explained, together with the file requirements for each. Two examples are carried through the process to show the actual use of the programs in performing an assessment of the change in risk attributable to changes in the fire performance of a specific product in a specified occupancy. This software was written for use on a mainframe or supermini computer. The software and this guide are intended for use by experienced users. It is not intended for use on micro computers.

1. Background

The Fire Risk Assessment Method is the result of a project funded by a broadly based consortium of manufacturers and trade associations through the National Fire Protection Research Foundation (NFPRF). It builds on recent advances in deterministic fire modeling to provide a physics-based method of estimating the severity of specified fires while retaining the probabilistic framework of traditional risk analysis for estimation of the relative probabilities of various types of fires. This fire risk assessment method is designed to permit the quantitative prediction of the change in expected fire *fatalities*¹ per year attributable to changes in fire performance properties of combustible products (e.g., building contents and furnishings) in the context of their end use in specific occupancies. This procedure is complex and requires considerable effort before it can be applied successfully. It is advisable to examine the five reports [1-5] that describe and apply the methodology before pursuing the development of new scenarios with the software.

¹

The limit to fatalities is not inherent in the Risk Assessment Methodology described herein, but rather is a limitation of the current state-of-the-art embodied in the hazard assessment method upon which it is based. As the hazard assessment method is improved to consider injuries and property damage properly, the risks associated with these end points will be calculable.

1.1 Scenarios

The method is designed to calculate the expected severity (in deaths per fire) and the relative likelihood (as fire probability) of each of a large number of fire scenarios that may involve the product as the first item ignited or as a secondary contributor. Expected severity is estimated through the use of a computer-based hazard assessment method, which requires very specific information on the physical properties of burning items, the thermal properties of rooms in which fire occurs, the sizes and layout of rooms and their associated openings, the locations and conditions of occupants, and the status of built-in detection systems. Relative likelihood is modeled using fire incident data, data from other sources, and many assumptions since such information can be obtained only in terms of *classes* or ranges, e.g., class of burning items, classes of rooms, ranges of occupant ages.

The use of scenarios is the technique by which these two modeling components are joined together. The universe of possible fires and situations is divided into classes of scenarios, with each scenario being represented by a single, well-defined case, selected as the most average or typical case of the set of cases represented by the class.

The execution of this technique produces results somewhere between the extreme of (a) running the hazard assessment method once on the allegedly most typical case - a gross oversimplification that could not be reasonably expected to estimate overall risk and (b) the use of classes so precisely and narrowly defined that every class is completely homogeneous with respect to the properties of interest and the issue of typical or average becomes moot - an impractical approach which would require nearly infinite time and cost to compute and would have to use probabilities that were nearly all pure guesswork.

The selection of a best compromise between these two extremes requires many difficult and uncomfortable choices. Class definitions will inevitably be wide enough that they will encompass some fires or situations with significant differences, thereby placing importance on the process of designating an average case to represent them. At the same time, class definitions will inevitably be narrow enough that the best sources of information on relative likelihoods will not be sufficient, and one will need to use less satisfactory sources, including expert judgments.

Fire risk is measured in terms of the probability of a particular fire scenario and the consequence of that scenario as measured by the number of expected deaths. The method for calculating risk in a fire combines the likelihood of a fire, based upon fire incident databases, with the expected number of deaths due to that fire as predicted by the HAZARD I software. This technique allows for predicting how a change in the fire related properties of a product will change the risk to life safety of a given occupancy.

1.2 Overall Structure

The purpose of this paper is to show how the method described in detail in reference [1] was implemented on the computer. That is, what software was developed to carry out the calculations, together with the dependency on a particular computer. Some of the basic modules of the HAZARD I methodology have been modified slightly to allow for the statistical nature of this process. They will be noted. The examples employed in this report are drawn from the case studies used in the development of the method [2],[3],[4],[5].

The Fire Risk Assessment Methodology software is a collection of six programs. FAST, EXITRISK, and TENABRSK calculate the rooms conditions, the locations of the occupants, and the tenability conditions to which the occupants are exposed. SUMMARY computes the number of deaths for each scenario from the TENABRSK output. PRINTSUM produces a report of the SUMMARY output. STATCOMP prints a report showing the expected and actual number of deaths for a particular class of scenarios.

The intent of this user's guide is to provide the information necessary to install and use this collection of software for the Fire Risk Assessment Method. Technical information on the programs, FAST, EXITT and TENAB can be found in the HAZARD I documents [6] and is not repeated here. The computations performed in STATCOMP are discussed in the Fire Risk Assessment Methodology document [2]. A list of files associated with the Fire Risk Assessment Method is provided in Table 1.

1.3 Fire Risk Method

The general process of fire risk assessment is presented in section 1.2 of reference [1]. The universe of possible fires is divided into a collection of general but well defined scenarios. The probability of each scenario's occurrence is computed from data of the occurrence of actual fires. This data includes:

- 1) the type of building,
- 2) the room of origin,
- 3) whether the product is part of the room's fuel load,
- 4) the class (NFPA 901 category of first item ignited) from which the first item ignited is drawn, based on burning properties,
- 5) a distribution for the distance between first item and product, given the room,
- 6) whether the fire had a smoldering phase, based on its form of heat of ignition,
- 7) the time of day, and
- 8) whether an operational smoke detector was present.

These specifications are used to define building arrangements and fire growth curves for all possible fires involving the product in such buildings.

Possible occupant sets, that is, groups of people who might be expected to be in the building are characterized. The probability of each occupant set is computed from data on the general population. This process examines:

- 1) the number of occupants,
- 2) their relationships,
- 3) their capabilities (inferred from their sleep statuses),
- 4) ages, handicaps, impairments, and
- 5) the initial location of the people, inferred from likely activities based on time of day.

Once the buildings, fires, and occupants have been incorporated into the complete set of scenario descriptions, the RISK Software is used to process the cases and to obtain the results.

For a given fire scenario, a time line for heat, layer thickness, smoke density, and toxic gases in all modeled rooms is developed by FAST. If an operational smoke detector is in the building, its activation time is derived from the physical fire effects in its vicinity. EXITRISK (modified version of EXITT) then develops a time line of occupant locations for every occupant in every occupant set. The occupants begin to act and move in accordance with behavior rules abstracted from past studies of human behavior in fires when either the detector is activated or the fire effects are estimated to cause alerting of the occupants. From the time line for heat, layer thickness, toxic gases and occupant location, TENABRSK (a modified version of TENAB of HAZARD I) is used to determine whether, when and where each occupant died or escaped based on available data on tenability thresholds. This provides the number of deaths for that scenario and occupant set for that fire. The deaths-per-fire results for that scenario are estimated using the probability weighting factor for each occupant set (using SUMMARY). This process is repeated for each scenario.

When all scenarios have been processed, the fire scenario probability and the total number of fires are used to obtain the number of fires for that scenario. This is combined with the deaths-per-fire estimate for the scenario to obtain the number of deaths. These results are combined with similar results for all other scenarios to produce a sum that represents the estimated risk. This calculation is performed by the STATCOMP program.

Sections 2, 3 and 4 describe the details of the suite of programs. Section two describes each of the programs, their system dependencies and required input and output files. The third section describes the content and format for the data files associated with the software. The fourth section looks at automating the process. Sections 5 (overview) and six (example cases) provide a step by step procedure for the operation of the software.

1.4 Overview of the Program Structure

Figure 1 and Figure 2 illustrate the relationships between programs and input and output files. These programs are discussed in detail in the next section(s).

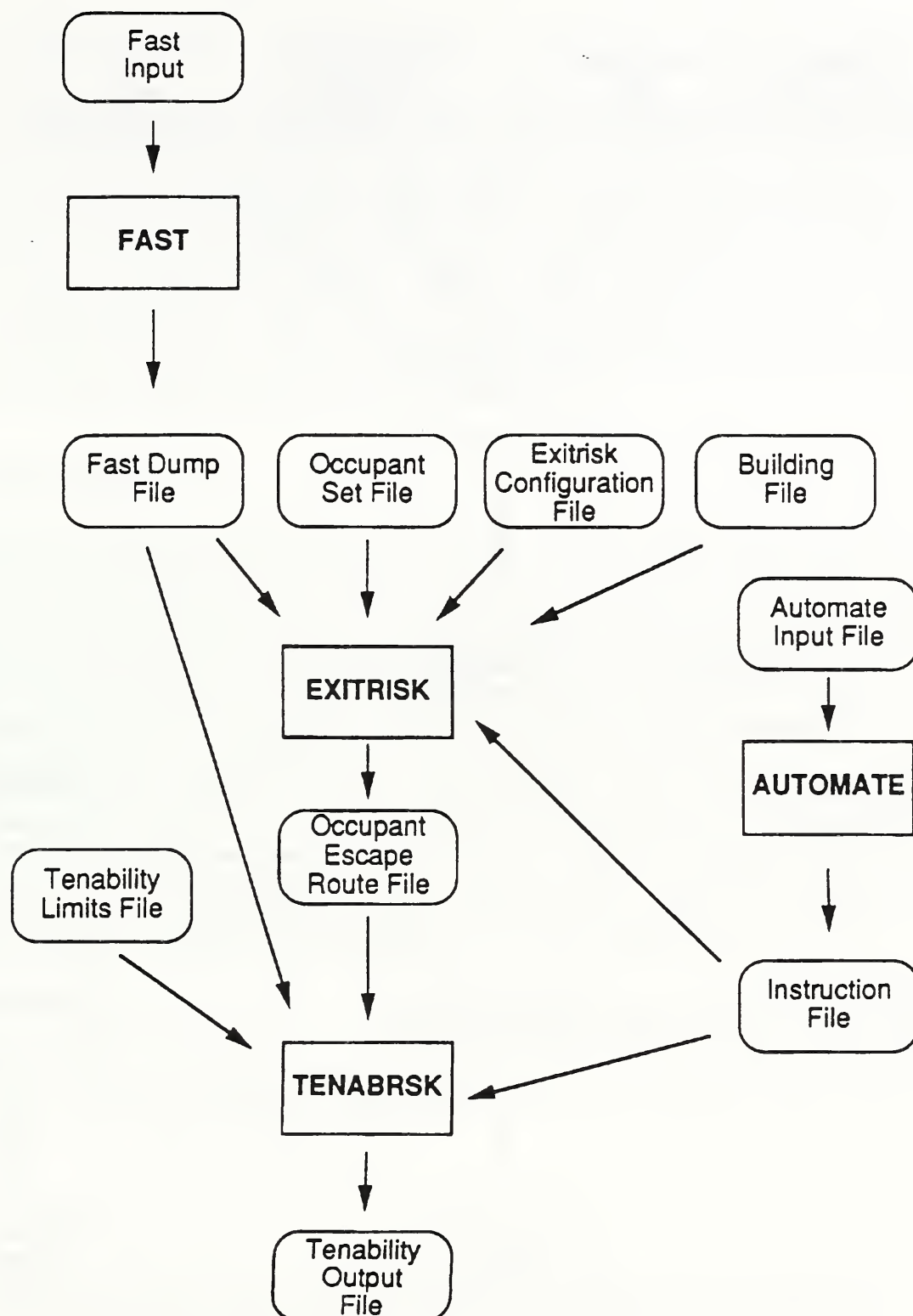


Figure 1 Flow chart for the risk analysis programs.

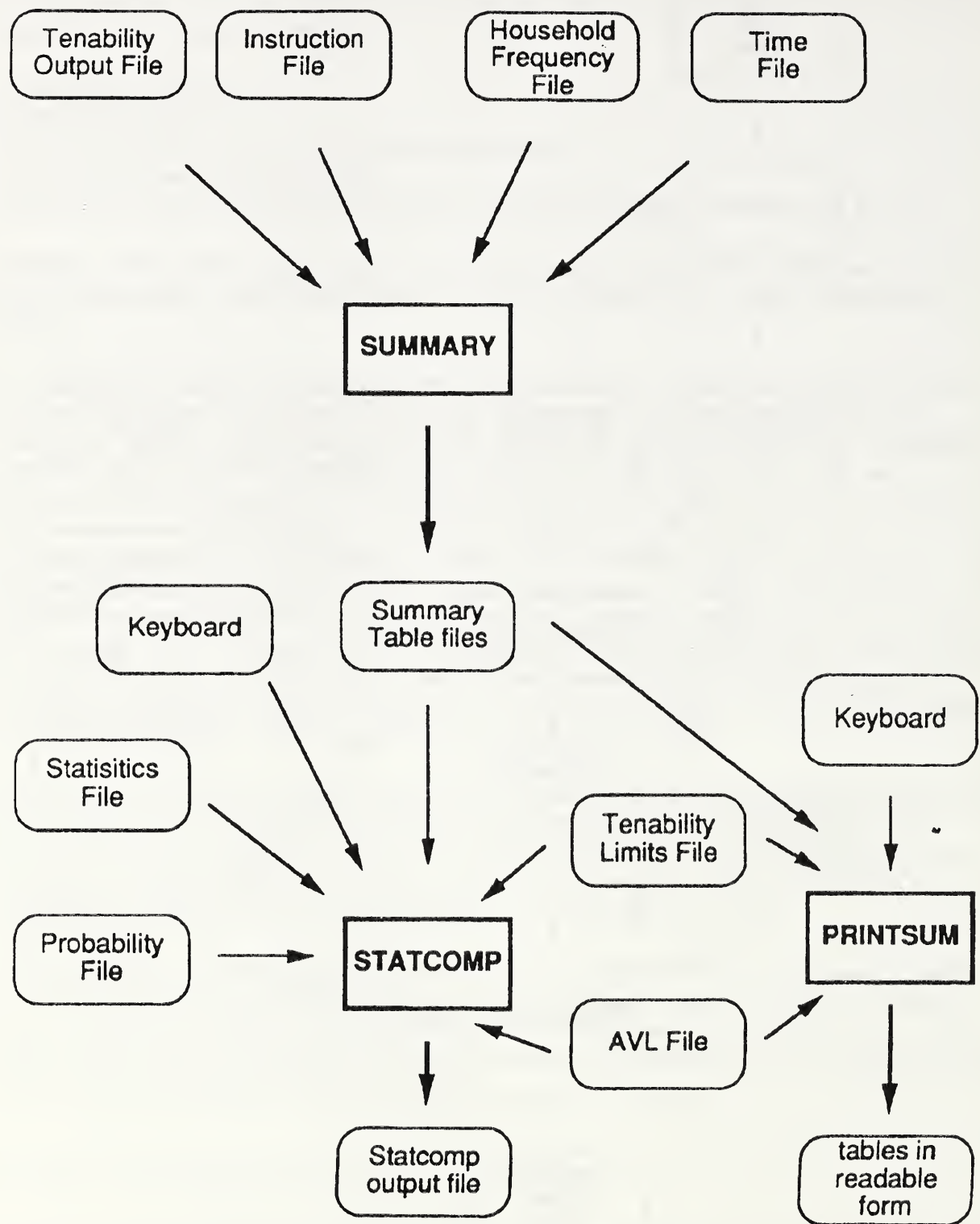


Figure 2 Flow chart for SUMMARY and STATCOMP.

2. Programs

The Fire Risk Assessment Methodology software consists of six programs: 1) FAST (and FFM); 2) EXITRISK; 3) TENABRSK; 4) SUMMARY; 5) STATCOMP; and 6) PRINTSUM. A seventh program, AUTOMATE, is a utility program for facilitating the processing of the different scenarios through EXITRISK, TENABRSK and SUMMARY. AUTOMATE is discussed in section 4 since it is not actually a part of the methodology. These programs were implemented on a Concurrent Computer Corporation 3242 computer system². It is one of a class of superminicomputers using 32 bit data address paths. Dependencies on this system are discussed for each program. Tables (2) and (3) provide a summary of this section. A brief discussion on the purpose, the system dependencies, and the required input and output files of each of these programs is given here.

2.1 The FAST Program

There are two versions of the fire growth and smoke transport model. The basic version is called FAST. The documentation for this version is contained in the Technical Reference Guide for FAST [7]. There are some additional data files required for the modifications necessary to implement the combustion model of burning objects used in case study #4. These are discussed here. The source for this primary version is in the file FAST.FTN. It consists of approximately 6300 lines of source code. There is an alternative version which supports the combustion algorithm. It requires the usual source files (see above), as well as additional data describing the pyrolysis and geometry of the fire. The source for the version which supports the combustion model is in the file FFM.FTN. It consists of approximately 13670 lines of standard FORTRAN. The additional keywords required to use this beyond those described in reference [7] are described below. In addition, if graphics is desired, the library routines, DEVICE.FTN [8] and the character set[9] which are part of this program must be included. The graphics is not integral to the operation of the model and may be excluded simply by deleting the call to the routines DISPLAY and ENDDIS.

There is an additional routine for showing a three dimensional perspective of the burning object, XYZPLOT.FTN. It too uses the DEVICE library. Once again, it is not essential. However, in order to realize the maximum amount of information that the model produces, the plotting programs should be utilized, in conjunction with the EXITT and TENAB programs.

²

The use of company names or trade names within this manual is made only for the purpose of identifying computer hardware or software products. Such use does not constitute any endorsement of those products by the National Institute of Standards and Technology.

2.1.1 FAST Source Files

The source files for FAST are FFM.FTN, XYZPLOT.FTN, DEVICE.FTN, HSET.FTN, NGROUPH.FTN, NHHSIZE.FTN, HSIZE.FTN. These files are all in standard seven bit ASCII. The routines used for modeling are FFM, XYZPLOT and DEVICE. Included on the tape is the DEVFONT.004 file which is generated from the ALPHA.DAT file by the translation program NGROUPH.FTN. These latter are the stroke fonts used by the graphics programs. NGROUPH will generate the complete set as listed in reference [8], and the others are for manipulating these fonts.

2.1.2 System Dependencies

There are two sources of system dependencies. The first are low level device drivers used by DEVICE. The second is the use of a operating system specific input/output call to increase the read/write data transfer rate for accessing the dump files generated by FAST.

The former consists of calls to routines to: 1) draw a circle, 2) draw a polygon, 3) draw a line, or series of connected line segments, 4) initialization of the appropriate devices, and change visual aspects such as color, line width, polygon filling type and line drawing type. These are very platform specific and will not be detailed further. Note that in linking the FAST or FFM code, these routines will still be "called." This will generate an error message indicating that the references have not been satisfied. If the calls to DISPLAY and ENDDIS have been deleted, as indicated above, then the routines will not be accessed, and no difficulties should be encountered. However, the actual routines which make these calls can be deleted as well. They are the graphics access routines such as VIEWTR, GRAFIT, PLYGON and so on.

The input/output dependence involves a routine, SYSIO which has the following arguments:

```
CALL SYSIO (IOP, COMMAND, IOUNIT, BUFFER, LENGTH, RANDOM ADDRESS)
```

where

```
IOP      = SIX WORD ARRAY, FOR THE I/O PACKET
COMMAND  = A NUMERICAL VALUE FOR READING (88) OR WRITING (56)
IOUNIT   = NORMAL FORTRAN I/O UNIT NUMBER
BUFFER   = A BUFFER ADDRESS
LENGTH  = NUMBER OF BYTES TO TRANSFER
RANDOM ADDRESS IS THE FORTRAN EQUIVALENT OF RECL=RECORD NUMBER
```

The system routine was used for speed considerations. The following two routines can replace the calls to SYSIO for read and write respectively. These will substantially decrease data transfer speed unless some equivalent system routine is available.

```
CALL DREADIN (TIN/4, INPUT, ?????)
      .
      .
      .
```

```

SUBROUTINE DREADIN (LENGTH, BUFFER)
DIMENSION BUFFER (LENGTH)
READ (9) BUFFER
RETURN
END

```

and

```

CALL WRITEOT (TIN/4,OUTPUT)
.
.
.
SUBROUTINE WRITEOT (LENGTH,BUFFER)
DIMENSION BUFFER(LENGTH)
WRITE(9) BUFFER
RETURN
END

```

2.1.3 Required Input Files

There are two files used in the basic operation of FAST. They are the data file which describes the scenario being simulated, and a file of thermophysical properties. Examples of both are included in section 3. Beyond the usual data to run the FAST model, there are additional files, and associated key words, needed to use the combustion model (referred to as a furniture fire model since it was written to predict fire development on upholstered furniture) [10]. The furniture fire model is used by setting the LFBO parameter in the main data file to 5. The additional data files describe the physical arrangement of the burning object, its flame spread properties and the combustion properties. These latter two come from the NIST LIFT (ASTM-1321) [11] and CONE (ASTM-1354) [12] apparatus respectively.

The additional key words recognized by the model to implement the burning object are

Label	Parameter	Comments
CONEF	(1)	Name of a CONE run data file. This key word may appear up to five times.
MOCKP	(1)	Name of the object descriptor.
BENCH	(1)	Name of the LIFT data file.

There is one subtle difference in using the furniture fire model. The time specified in the FTIME line is a single entry, and is the time between successive furniture calculations. Thus the order of a FAST run becomes

1. Initialize the whole data set
2. Calculate the first time step for the fire, using the FFM
3. Do sub interval calculations for the transport phenomena using the standard FAST model
4. Go back to step 3 until the FAST time step catches up with the furniture fire model. Then go back to step 2 and loop over 2-4 until the simulation is finished.

The change in time step parameters carries over to the "times" line as well. The time specified by the FTIME key word effectively becomes the δt for the whole simulation. Since the TIMES line specifies the time step intervals, the simulation time is the number of time steps times the FTIME parameter. The print and dump intervals are treated in a similar way. This is not actually different than the correct interpretation, but most have become accustomed to thinking of the TIMES line as representing seconds. One must be aware of the actual meaning in interpreting the output from the model, or using the results. The time reported in the output is the correct time in seconds.

2.1.4 Output from FAST

In all cases, output from the model will be that shown in the Technical Reference Guide [13]. When the furniture model is being used, there is additional output available for diagnostics. The level of output available in this model is determined by an option in the bench case data file. It is the last number on the last line of the file. A value of zero prevents all extra output, 1 and 2 are time histories, 3 is the normal output and produces a file on unit 13 (see the Command Substitution System files used to run the model) which can be plotted with XYZPLOT. It is a three dimensional perspective of the burning object.

2.2 The EXITRISK Program

EXITRISK determines the escape routes and evacuation times for the occupants in a residential fire. The escape routes are determined according to some specific rules of occupant behavior and the level and density of smoke in the rooms. Occupant movements begin when either a smoke detector is activated (if present) or when the fire effects are estimated to cause alerting of the occupants.

EXITRISK is a modified version of the FORTRAN program EXITT documented in HAZARD I. It is designed to produce a time line of occupant locations based on room layer heights and smoke densities provided by a FAST dump file(s). EXITRISK is not interactive; however, it expects to access an "Instruction" file; a file containing the names of all other input and output files required by EXITRISK.

EXITT of HAZARD I and EXITRISK differ in that EXITT processes only 1 occupant set per run while EXITRISK can process more than one occupant set per run. Rather than run EXITT once for each occupant set and creating an output file for each occupant set,

EXITRISK loops through a collection of occupant sets and creates one output file. Because of this basic difference, other changes had to be made. One change is that the building/occupant set file of EXITT was split into two files for EXITRISK, a building file and an occupant set file. Another change is that the time line for room layer heights and smoke densities is read in once and stored as a matrix rather than reading in the time lines each time a new occupant set is processed. The last change is that only one output file is produced. This output file is designed to be read by TENABRSK.

2.2.1 EXITRISK Source Files

There are three source files required for EXITRISK. They are EXITRISK.FTN, NTRFACEX.FTN and FASTREAD.FTN. EXITRISK.FTN contains the main program as well as all other subroutines needed for EXITRISK except for the routines associated with reading the FAST dump files. These routines are located in NTRFACEX.FTN and FASTREAD.FTN. NTRFACEX.FTN and FASTREAD.FTN allow EXITRISK to access the number of rooms in the building, the burn room, and the interface height and upper layer smoke density for each room over time from the FAST dump file.

2.2.2 System Dependencies

In EXITRISK.FTN there are a few system dependencies. In the sub-program BLOCK DATA FIRST, the constants SPUNIT and INFILE need to be defined appropriately. SPUNIT refers to the console screen which is C: on the computer system used at NIST. The constant INFILE is set to the name of the file containing a list of all input and output files and other pertinent information for running EXITRISK (which will be referred to as an Instructions File). In the code, INFILE is set to 'FILENAME'. Should 'FILENAME' not be a valid name, it should be set to some arbitrary valid filename. The third system dependency is the function DATE called from subroutine GETSET. DATE(IDATE) returns the current year, month, and day in the integer variables IDATE(1), IDATE(2) and IDATE(3), respectively.

The source file NTRFACEX.FTN is system independent. However, because NTRFACEX.FTN is associated with reading the FAST dump files, it must be modified appropriately whenever the format of the FAST dump file is changed.

The source file FASTREAD.FTN is used to read FAST dump files. If the FAST dump file format is changed, the routines in FASTREAD.FTN will have to change accordingly. See section 2.1.2 on the system dependencies of FAST.

2.2.3 Required Input Files

There are 5 files required by EXITRISK. The first file is the "Instruction" file known as 'FILENAME' on the Concurrent system. This file provides EXITRISK with the names of the input and output files needed. The second file is the FAST dump file. The FAST dump file provides EXITRISK with the number of rooms in the building, the burn room, and the

interface height and upper layer smoke density for each room over time. The third file is the "EXITRISK Configuration" file. This file provides EXITRISK with two parameters, an initial trigger smoke interface height and a doubling stimulus trigger smoke interface height (see discussion in section 3.4.1 of reference [2]). The fourth file is the "Building" file. The Building file provides information about the building layout, noise levels and smoke detectors. The fifth file is the "Occupant Set" file. This file describes the people in each occupant set. The contents of these files is discussed in sections 3.4, 3.3, 3.5, 3.6, and 3.7, respectively.

2.2.4 EXITRISK Output File

One output file is produced by EXITRISK having the form of the "Occupant Escape Route" file. It is a sequential, formatted file having record length 32. This file contains the locations of the occupants over time. The content of this file is discussed in section 3.8.

2.3 The TENABRSK Program

TENABRSK estimates, for each occupant of a burning building, fractional effective doses due to gases, FED (a variation of FED used in HAZARD I), FEDP (Purser) and FEDCO₂, the exposure to radiant energy which might cause burns on exposed skin (FLUX), the integrated concentration-time product (CT), Oxygen depletion, and exposure to convective heat (TEMPA and FEDTEMP) from the data generated by FAST (version 18.3) to which the occupant is exposed while evacuating the building. TENABRSK is a modified version of the FORTRAN program TENAB, documented in HAZARD I. It is designed to be used with a dump file(s) from a run of FAST and an "Occupant Escape Route" file. The output from TENABRSK serves as the input for the program SUMMARY. Unlike TENAB, TENABRSK is not interactive. TENABRSK expects to access the same "Instruction" file that EXITRISK required.

2.3.1 TENABRSK Source Files

There are three source files required for TENABRSK. They are TENABRSK.FTN, NTRFACT.FTN and FASTREAD.FTN. TENABRSK.FTN contains the main program as well as all other subroutines needed for TENABRSK except for the routines associated with reading the FAST dump files. These routines are located in NTRFACT.FTN and FASTREAD.FTN. NTRFACT.FTN and FASTREAD.FTN extract the interface height, and the upper and lower layer temperature, CO, CO₂, HCN, CT, Flux, and O₂ levels in each room over time, the burn room and the number of rooms in the building.

2.3.2 System Dependencies

In TENABRSK.FTN there are a few system dependencies. In the sub-program BLOCK DATA FIRST, the constants SPUNIT and INFILE need to be defined appropriately. SPUNIT refers to the console screen which is C: on the Concurrent system. The constant INFILE is set to the name of the file containing a list of all input and output files and other

pertinent information for running TENABRSK (also referred to as an "Instruction" file. INFILE is set to 'FILENAME', but should 'FILENAME' be invalid for a particular system, it can be set to some arbitrary valid filename. The third system dependency is the function DATE called from subroutine GETSET. DATE(IDATE) returns the current year, month, and day in the integer variables IDATE(1), IDATE(2) and IDATE(3), respectively.

The source file NTRFACT.FTN is system independent. However, because NTRFACT.FTN is associated with reading the FAST dump files, it must be modified appropriately whenever the format of the FAST dump file is changed.

The source file FASTREAD.FTN is used to read FAST dump files. If the FAST dump file format is changed, the routines in FASTREAD.FTN will have to change accordingly. See section 2.1.2 on the system dependencies of FAST.

2.3.3 Required Input Files

There are 4 files required by TENABRSK. The first file is the "Instruction" file known as 'FILENAME' on the Concurrent system version. This file provides TENABRSK with the names of the required input and output files. The second required file is the FAST dump file(s). This file provides TENABRSK with the interface height, and the upper and lower layer temperature, CO, CO₂, HCN, CT, Flux, and O₂ levels in each room over time, the burn room and the number of rooms in the building. The third required file is the "Occupant Escape Route" file. This file provides TENABRSK with the locations of the occupants over time. The fourth required file is the "Tenability Limits" file. This file provides TENABRSK with the criteria for determining when a person becomes incapacitated or dead. The format and contents of these files is discussed in sections 3.4, 3.5, 3.8, and 3.9, respectively.

2.3.4 TENABRSK Output File

One output file is produced by TENABRSK. It contains information about each occupant concerning whether they successfully escaped out a door or window, became incapacitated or dead, or were still alive, but in the building at the end of the simulation time. The contents of the Tenability file is discussed in section 3.10.

2.4 The SUMMARY Program

SUMMARY summarizes each Tenability Output file. It creates 3 sets of six tables. Table 1 is the number of deaths per fire per scenario; Table 2 is the number of deaths per fire by cause of death; Table 3 is the number of deaths per fire per scenario by occupant type; Table 4 is the number of occupants going to windows per fire per scenario by occupant type; Table 5 is a frequency count of the number of people who attempt to escape through a window by household size and Table 6 is a frequency count of the number of occupant deaths per fire per scenario by household size. The three sets of tables differ in the way in which "window people" (people who attempt to escape out a window) are treated and whether or not

rescuers can arrive (see section 3.4.1, figure 10, in reference [2] for the application of this approach in Case 1. In Summary set 1, window people are considered to have escaped if they are "alive" after a specified number of seconds after arriving at the window. This specified time is the assumed time it would take to open the window. In Summary set 1, no rescuers come. In Summary set 2 all window people are considered to have escaped once they reach a window and no rescuers come. Summary set 3 is like set 1, except rescuers can come. Occupants who are alive in the building 10 minutes after the first person escapes are considered to have been rescued and will not die. SUMMARY is a non-interactive FORTRAN program. Like TENABRSK and EXITRISK, it expects to access the "Instruction" file used by EXITRISK and TENABRSK.

2.4.1 Summary Source Files

There are two source files required for SUMMARY. They are SUMMARY.FTN and CRAVL.FTN. SUMMARY.FTN contains the main program as well as all other subroutines needed for SUMMARY, except for the routines associated with the master list of scenarios run under a certain set of conditions. CRAVL.FTN contains routines for managing these sets of scenarios. The CRAVL routines create and update an AVL file. The AVL file contains a list of scenarios which have been run, the groups to which those scenarios belong, the indices into the summary table files to which those scenarios correspond, and the indices in the statistics file to which those scenarios correspond. Each scenario is assigned to a group designated by the user. The group number allows the user to partition the set of scenarios into subsets. This group number is used by PRINTSUM and STATCOMP for purposes of printing out information on a subset of scenarios. If the user desires, all scenarios can be assigned to group 1, i.e. no partitioning is desired.

2.4.2 System Dependencies

There are two system dependencies in SUMMARY.FTN. The constants SPUNIT and INFILE need to be defined appropriately in the sub-program BLOCK DATA FIRST. SPUNIT refers to the console screen which is C: on the Concurrent system. The constant INFILE is the name of the Instruction file. INFILE is set to 'FILENAME' on the Concurrent system, but can be set to some arbitrary valid filename on other systems.

The source file CRAVL.FTN is system independent.

2.4.3 Required Input Files

There are 4 files required by SUMMARY. The first file is the "Instruction" file known as 'FILENAME' on the Concurrent system version. This file provides SUMMARY with the names of the files it needs. The second file is the "Tenability Output" file. This file contains information concerning the tenability conditions experienced by each occupant. The third file is the "Household Frequency" file. This file contains the number of households composed of a particular occupant set. A fourth file is the "Time" file. This file contains the times it is

assumed to take different occupant types to open a window and get out. The contents of these files is discussed in sections 3.4, 3.10, 3.12, and 3.11, respectively.

2.4.4 Summary Output Files

SUMMARY writes to 3 different sets of 6 files. Each time SUMMARY is run the 3 sets of 6 files are updated with the summary information associated with the TENABRSK output file. Each set of 6 files represent 6 tables. The files associated with tables 1-4 are direct access, formatted files having logical record length 64. Tables 5-6 are direct access, formatted files having logical record length 132. The contents of these files is discussed in section 3.13.

SUMMARY also creates and updates the master list of scenarios for each set of conditions. A set of conditions is defined by a product number, an EXITRISK Configuration file, an Occupant Set file, a Tenability Limits file, a Household Frequency file, and a Time file. This master list is referred to as the AVL file.

2.5 The STATCOMP Program

STATCOMP prepares two reports for the user. The first report shows the expected number of deaths per fire computed from summary table 1 and the scenario likelihoods and gives the statistical number of deaths per fire and their associated probabilities. A table is given for each time of day (day, evening and night) as well as a table for day, evening and night cases. For each time of day, totals are given for all scenarios, as well as for flaming and smoldering scenarios. The second report gives, for each time of day, the percent of deaths due to each tenability measure. The STATCOMP output is produced for a particular group of scenarios. The grouping is discussed in section 3.4, the Instructions file.

STATCOMP is an interactive FORTRAN program.

2.5.1 STATCOMP Source Files

The modules for the STATCOMP program are STATCOMP.FTN and CRAVL.FTN. STATCOMP is dependent on the scenario/filename naming convention used for the particular case being run.

2.5.2 System Dependencies

There are a few system dependencies in STATCOMP.FTN. One is where the console screen is opened. The file/device name for the screen is 'C:'. It should be replaced with an appropriate name if necessary. The unit attached to the screen is given by SCREEN=10. It should be set to an appropriate unit number for other systems.

Subroutine INDEX3 selects the appropriate probability for the door status (open or closed) based on the scenario name. Subroutine INDEX4, likewise selects the appropriate probability

for the type of building (e.g., in the residential case, this was ranch = 70% and two story = 30%). These two routines are dependent upon the file naming convention used during development.

2.5.3 Required Input Files

STATCOMP requires the following files: SUMMARY tables 1 and 2 for a particular set, the associated AVL file, the associated tenability limits file, a probability file for door status, building type and detector status, PROBAB.DAT, and a statistics file, STATS.DAT.

2.5.4 Output File

STATCOMP outputs 2 files. The first file contains information on the actual and estimated number of deaths for a scenario. The second file contains information on the per cent of deaths attributed to each tenability measure.

2.5.5 Running STATCOMP

STATCOMP requires three pieces of information. The first piece of information is the root name of the AVL (the master list of scenarios) file. As set up, this will be a character string of length 6. Positions 1-6 correspond to the indicators for the Tenability Limits file, the EXITRISK Configuration file, the Occupant Set file, the Household Frequency file, the Times file and the product number. The second piece is which method of counting deaths to use (i.e. which set, 1,2, or 3 of the summary tables). The last piece of information is which group of scenarios to use.

2.6 The PRINTSUM Program

PRINTSUM prints out the summary tables in a labelled, formatted manner for the user to view. It is an interactive FORTRAN program.

2.6.1 PRINTSUM Source Files

The modules for the PRINTSUM program are PRINTSUM.FTN and CRAVL.FTN. PRINTSUM is dependent on the scenario/filename naming convention used for development.

2.6.2 System Dependencies

There are a few system dependencies in PRINTSUM.FTN. One is in the line where the console screen is opened. The file/device name for the screen on the Concurrent is 'C:'. It should be replaced with an appropriate name, if necessary. The unit attached to the screen is given by SCREEN=10. It should be set to an appropriate unit number for other systems.

2.6.3 Required Input Files

PRINTSUM requires the following files: a set of SUMMARY and AVL files and the associated tenability limits file.

2.6.4 Output File

PRINTSUM outputs 6 files, one file for each table of a specified SUMMARY table set.

2.6.5 Running PRINTSUM

PRINTSUM requires three pieces of information. The first piece of information is the root name of the AVL (the master list of scenarios) file. As set up this will be a character string of length 6. Positions 1-6 correspond to the indicators for the Tenability Limits file, the EXITRISK Configuration file, the Occupant Set file, the Household Frequency file, the Times file and the product number. The second piece is which method of counting deaths to use (i.e. which set, 1,2, or 3 of the summary tables). The last piece of information is which group of scenarios to use.

3. Input and Output Files

In the previous section, the programs of the method were described and their required input and output files were discussed. These input and output files are the topic of this section. The content and format for these files is described below. Table 4 provides a list of these files along with a brief description of the file and information on which programs use them.

3.1 Fast Input File

The format for the data (input) files follows the standard as elaborated in reference [6]. Two annotated examples are shown in section 6.1.1 and 6.2.1. These are the two used in the sample calculations in section 6.

3.2 Fast Database Files

There are four types of data files required for this version of FAST. The thermophysical data, the cone calorimeter profiles, the ignition data and the mockup. The first is described in reference [7]. An *example* of each is

thermophysical properties

GYPSUM .16 900. 800. .016 .9 0.0063 2.56E11 3.52 1786.
 BRICK1 0.18 900. 790. 0.016 0.9
 CONCRETE 1.7 1000. 2200. 0.15 0.94
 CONCRETE 1.7 1000. 2200. 0.15 0.94
 REDOAK 0.15 1300. 640. 0.025 0.99
 GLASS 1.40 760. 2500. 0.002 0.1
 WXW 0.134/0.134 1062./1062. 800./800. 0.0254/0.0254 .9
 CARB4 1.7 1000. 2200. 0.10 0.94
 CARB2 1.7 1000. 2200. 0.05 0.94
 GYP1/2 0.12 900. 800. 0.012 0.9
 GYPAIR 0.12/0.026/0.12 900./1040./900. 800./1.1/800. 0.025/0.051/0.025 0.9
 CONAIR 1.7/0.026/1.7 1000./1040./1000. 2200./1.1/2200. 0.051/0.051/0.051 0.94

physical description (mockup)

1 0.05 0.61 0.61 5.28 90.0 0.3317000
 1 0.05 5.28 5.23 2.00 90.0 1.1320000
 1 0.05 0.61 0.61 2.00 90.0 0.1413444
 1 0.05 5.28 5.28 2.00 90.0 1.1320000

0.0 0.61 0.0 90.0 0.0 0.0
 5.28 0.0 0.0 180.0 85.0 0.0
 0.0 0.0 0.0 180.0 85.0 90.0
 0.0 0.61 0.0 180.0 85.0 180.0

0 3 0 4
 3 0 2 0
 0 2 0 0
 4 0 0 0

0 1 0 0
 1 0 3 0
 0 3 0 0
 0 0 0 0

0 1 0 2
 1 0 4 0
 0 4 0 0
 2 0 0 0

0 1 0 3
 1 0 0 0
 0 0 0 0
 3 0 0 0

0 0.1
 1 2

cone calorimeter

1 30. 175. 370. 1 0.004
 ATMI MAT-Q 30 KW/M2 VERT TEST 2270
 WALL COVERING ON GYPSUM BOARD
 SOOT AVERAGE 0.0435960
 EXT. AREA AVG. 158.4
 HEAT OF COMB 4.10
 TIME TO IGNITION 175.7 S
 MASS CONSUMED 10.1 G
 TOTAL HEAT RELEASE 3 MJ/M2

```

175.0 10.4 0.13 0.930 11.1 0. 1.35 0.0011 0.5552 0.0095 0.0 0.0
180.0 91.2 0.59 7.040 12.95 0. 1.19 0.0013 0.4026 0.0085 0.0 0.0
185.0 147.2 1.32 12.61 11.67 0. 1.05 0.0014 0.3550 0.0111 0.0 0.0
190.0 137.1 2.01 14.16 9.68 0. 0.77 0.0030 0.2939 0.0128 0.0 0.0
195.0 99.80 2.51 13.20 7.56 0. 0.46 0.0039 0.3553 0.0261 0.0 0.0
200.0 045.6 2.74 08.39 05.44 0. 0.43 0.0072 0.4223 0.0336 0.0 0.0
205.0 015.6 2.81 03.70 04.21 0. 0.47 0.0094 0.5433 0.0300 0.0 0.0
...
315.0 1.0 3.00 0.44 2.31 0.0 0.67 0.0021 0.5461 0.0122 0.0 0.0
320.0 1.5 3.01 0.70 2.16 0.0 0.72 0.0023 0.5967 0.0127 0.0 0.0
370.0 1.0 3.07 0.44 2.32 0.0 0.72 0.0021 0.6718 0.0114 0.0 0.0

```

LIFT apparatus, or flame spread data

```

1.0      0.0      0.19    300.
0.0      0.85     0.015  473.  22.5  0.456
20.0     1.342    0.6328 223.5  1      1      0.1    1.0
1.2845   0.4      700.0  9.82   0.0  1250.  0
0.25     0.146    0.121   3

```

Only the fourth represents a complete data set. The intent is to give a feeling for the appearance of the data files for diagnostic purposes.

3.3 Fast Dump File

The dump file is used to record the time varying parameters. It is a binary file, and is not directly accessible by the user. All of the Risk programs access this file type through the routines DUMPER, RESTRT and OUTPU.

3.4 The Instruction File

The Instruction file provides the list of all files required by EXITRISK, TENABRSK and SUMMARY for a particular scenario. The first line is an integer which is five plus the number of dump files, NODMP, for a particular scenario. The next NODMP lines contain the dump file names. Each successive file should continue from where the previous dump file stopped. These sequential dump files are only produced when the FAST restart feature is used as in CASE 1. The next 6 lines contain the Occupant Escape Route, TENABRSK Output, the Building, the Occupant Set, the Tenability Limits and EXITRISK Configuration file names.

The next section tells how many scenarios share the given FAST dump file. Each scenario's simulation time is determined by when the burn room reaches a predetermined upper layer temperature. The first line of this section tells how many scenarios share the given FAST dump files, NOSCENARIO. The next NOSCENARIO lines give a temperature in degrees Celsius (when the upper layer of the burn room reaches this temperature the simulation ends), a scenario name, a product number and a five character indicator for which input files are associated with this case.

The next two lines give the names of the Household Frequency (section 3.12) and Time (section 3.11) files. The next line gives the group number for the scenario and the index to the associated data in the statistics file. The group number is an arbitrary numbering (the group number should be between 1 and 25) assigned by the user. It provides the user with the ability to partition the set of scenarios into subsets. The group number is used by STATCOMP and PRINTSUM as a way of specifying a subset of scenarios for which information is desired. If partitioning is not desired, each scenario should be assigned to group one.

The last section contains 21 lines of filenames. The first group of 7 lines are the names of the 6 summary tables plus the AVL file associated with the death count method where people at windows do not necessarily escape and no outside rescuers come. The next 7 file names are for the death count method where people at windows are considered to have escaped and the last 7 lines are the file names associated with the death count method where window people might not escape, but outside rescuers can come 10 minutes after the first occupant of the set escapes.

EXITRISK, TENABRSK, and SUMMARY always expect the instruction file to have the name assigned to the variable INFILE (see sections 2.2, 2.3, and 2.4).

3.5 The EXITRISK Configuration File

The EXITRISK Configuration file contains two parameters, an initial trigger smoke interface height and a doubling stimulus trigger smoke interface height. See section 3.4.1 of Case Study I [2].

3.6 The Building File

The Building file provides the EXITRISK program with the layout of the building (node, room, door, and window locations and the distances between nodes), the relationship between EXITRISK node numbers and FAST room numbers, the relationship between EXITRISK node numbers and EXITRISK room numbers, number and location of smoke detectors, when the detector will sound, and the sound level of each smoke detector alarm in each room when sounding and the ambient noise level in each room.

The building file format is described below. The building file contains seven sections. The entries on a line must be separated by a comma and/or a blank. **WARNING: There is no error checking for too few or too many entries on a line.**

The first section consists of a line containing two integers. The first integer indicates the number of rooms associated with the FAST dump file (which will be between 1 and 11) and the second integer represents the number of nodes (a node is a room, a location within a

room, a door or a window) in the EXITRISK floor plan. The maximum number of nodes allowed is 100.

The second section contains the mapping between the EXITRISK nodes and the FAST dump file room numbers and the EXITRISK nodes and the EXITRISK room numbers. If there are NRM rooms in FAST, then "FAST" room number NRM+1 corresponds to a door of EXITRISK (outside) and NRM+2 corresponds to a window of EXITRISK. If there are N nodes for EXITRISK, then the first line of this section consists of a line of N "FAST" room numbers with the first entry corresponding to node 1 of EXITRISK, the second entry corresponding to node 2 of EXITRISK, etc. In order to "cluster" nodes together into rooms, a mapping between EXITRISK nodes and EXITRISK room numbers is needed. If there are N nodes for EXITRISK, then the second line of this section consists of N "EXITRISK" room numbers with the first entry corresponding to node 1 of EXITRISK, the second entry corresponding to node 2 of EXITRISK, etc. The EXITRISK room numbers may not be the same as a window or door node number and window and door nodes should be assigned to the EXITRISK room in which they are located.

The third section consists of a line of N non-negative floating point numbers representing the node height. The node height is the distance between the floor level and the ceiling (meters) at the node.

Since the FAST model is limited to a total of eleven rooms, several rooms of an actual building may have to be combined for the model run. If the combined rooms have different floor heights, EXITRISK must have that information to determine the exposure conditions at each node within the building (for example, a room with a balcony where a node is "in" the balcony 2.4 meters above the floor of the room containing the balcony). The fourth section consists of a line of N non-negative floating point numbers representing the floor height of the node (in meters) above the floor of the room.

The fifth section is a line of NN (total number of nodes used by EXITRISK) integers representing the ambient noise level in decibels associated with each EXITRISK node.

The sixth section gives the smoke detector information. The first line of this section indicates the number of smoke detectors in the building, NSD (a maximum of 10 is allowed). If there is at least one smoke detector a second, third and fourth line for this section are required. The second line consists of NSD real numbers indicating the time each alarm will sound. If an entry is non-negative the alarm will sound at that number of seconds; if an entry is negative, then the EXITRISK program will determine when that particular alarm will sound. The third line consists of NSD integers representing the node location associated with each detector, the first entry being associated with the location of the first detector, the second entry being associated with the location of the second detector, etc. The fourth line consists of NSD rows, one row per detector. Each row contains NN integers representing the loudness of the detector in decibels at each EXITRISK node when the detector is sounding. A rule of thumb for determining these levels is that for the node at which the detector is sounding, the level is 95 decibels. Twelve decibels are lost for nodes farther away from the

detector, 12 decibels are lost in "going" through a closed door and 12 decibels are lost for a node on a different floor from that of the sounding detector's floor.

The seventh section consists of the distances between adjacent nodes (two nodes are adjacent if one can travel from one node to the other without going through any other nodes). The first line of this section contains an integer indicating the number of edges (an edge is an adjacent pair of nodes), NEDGES. The second through NEDGES+1-st lines each contain 2 integers and a non-negative floating point number. The first integer represents the "from" node, the second integer represents the "to" node and the floating point number represents the distance in meters between the two nodes. If the distance between nodes x and y is d, the distance between y and x is assumed to be d unless the file specifies that the distance between y and x is otherwise. This may occur, for example, in the case of a stairwell, where going up the stairs from node x to y takes longer than going down the stairs from node y to x.

3.7 The Occupant Set File

The Occupant Set file describes to EXITRISK the characteristics of the occupants in the building. Each occupant set is represented by a block of lines 1 + the number of occupants in the set.

The first line of each set consists of 5 2-digit codes indicating the type of occupants in the set (columns 1-10), a 1-digit smoke detector status indicator (0=no detector, 1=working detector) (column 11) and the number of occupants in the set (column 16). There is a maximum of 5 occupants per set. The next n lines where n is the number of occupants in the set contain the occupant type (11, 13, 21, 23, 31, 33, 41, 43, 51, 53, 62, 63, 74), their age, sex (1=male, 0=female), EXITRISK node starting location, ability to egress on their own (1= needs help to evacuate, 0=capable of egress on own), awake status (1=awake, 0=asleep), sleeping penalty and travel speed in m/s (refer to Appendix C of NIST Handbook 146, Vol II, Technical Reference [6]). For occupants who are not asleep, the sleeping penalty is 0. For occupants who have difficulty waking, such as occupants who have hearing loss and young children, the penalty assigned is between 0 and 50. decibels. For occupants who wake easily, such as mothers of infants, the sleeping penalty assigned is between -15 and 0 decibels. For travel speeds, a non-positive number indicates that the default speed of 1.3 m/s is to be used. A positive number is interpreted as being the travel speed of the occupant in m/s.

3.8 The Occupant Escape Route File

The Occupant Escape Route File contains information about the files associated with the creation of the file and the actions of the occupants in each set. This file is read by TENABRSK to track the locations of the occupants over time. An Occupant Escape Route file is created by EXITRISK. However, if another method for egress is to be substituted for

EXITRISK (as was done in case studies 2, 4, and part of 3), an output file of this form must be made in order for TENABRSK to be used.

The first line gives the version number (columns 2-5), the creation date (columns 7-14), and the run date (columns 15-22). The next group of lines gives the fast dump filenames used, followed by the Occupant Escape Route File name, the building filename, and the EXITRISK configuration file name. For each of these filenames, the filename begins in column 2 of the line. The next line gives the occupant set filename. In column 1 of this line is a \$ sign and beginning in column 2 is the filename. This \$ indicates the end of the filename section. Should this file be created by another means other than by EXITRISK, the first line of the file can be blank and the second line should have a \$ sign in column 1. The information above the \$ serves as information about the Occupant Escape Route file only.

On the next line, right justified in columns 1-5 is the number of EXITRISK nodes. The next lines give the mapping between EXITRISK nodes and FAST room numbers (See Building File). These values are written 5 to a line, right justified in columns 1-6, 7-12, 13-18, 19-24, and 25-30.

Occupant set movements are recorded in blocks for the rest of this file. The first line of each block gives the occupant set label in columns 1-10, the detector status (0=working, 1= not working) in column 12 and the number of people in the set, right justified in columns 13-17. The next lines indicate the location each of the occupants as they move about. Each line gives the occupant number, right justified in columns 1-6, the occupant node location, right justified in columns 7-12, the time (in tenths of seconds as the unit of time), right justified in columns 13-18, and the floor elevation height, in columns 19-26 with the decimal in column 24. The end of an occupant set is given by an entry of 0 in columns 6, 12, and 18 and an entry of 0. (real) in columns 23-24.

3.9 The Tenability Limits File

The Tenability Limits file sets the incapacitation and lethality levels of the tenability measures and the parameters for determining to which layer in a room a person is exposed.

The first line of this file contains the incapacitation levels for each of the 8 tenability measures. The second line of this file contains the lethality levels of the 8 tenability measures. The third line contains an upper and lower bound (m) on the interface height and a critical temperature (degrees C). The order of the 8 tenability measures is as follows: FED1, TEMP1, CT, FLUX, FED2, TEMP2, FED3, O2DEPLETION. Refer to Chapter 7 and Section 8.5 of the HAZARD I Technical Reference [6]. To "turn off" a measure, set the limits for that measure at "infinity". In the Fire Risk Assessment Methodology development, the incapacitation and lethality levels were set to the same values for each measure. This represents the assumption that when a person is incapacitated, they will collapse and succumb. In creating this file entries on a line need only be separated by blanks or commas.

3.10 The TENABRSK Output File

The Tenab Output file contains information about the run followed by the conditions experienced by the occupant whenever an event occurred. An event is when the person reaches a window, escapes, becomes incapacitated, dies, or the end of the simulation time occurs, but the occupant has experienced no other events.

The first line of the file states the FAST and EXITRISK versions that were used, the creation date of TENABRSK and the date the file was produced. The next group of lines are the FAST dump files used in the run, with one filename per line. The next 2 lines give the tenability limits that were used in creating the file. The next group of lines tell the end of simulation time for the associated tenab files. The first line indicates how many associated files there are. The next lines give the final simulation time for those scenarios.

The rest of the lines appear in "blocks" with one "block" per occupant set. The first line of a block is the occupant set label (columns 1-10), the status of the smoke detector (column 12), the number of occupants in the set (right justified in columns 13-15), and the earliest escape time of all the occupants in the set (columns 17-30 with the decimal in column 21). Then, for each occupant, there is a line containing the occupant type, 2 8-digit codes, the number of events experienced by the occupant (a maximum of 3 could occur), followed by the time, location of the occupant, and event type for each of the events. The occupant label is in columns 1-2, and the first 8-digit code is in columns 4-11, and the second 8-digit code is in columns 12-19. The 8-digit code indicates the causes of incapacitation and death, respectively. Positions 1-8 represent the tenability measures FED, TEMP, Ct, Flux, FEDP, Convective Heat, FEDCO and O2 depletion, respectively. A 1 in position i indicates that the measure corresponding to the i'th position exceeded the tenability criteria and was a cause of incapacitation or death. The event count is in column 20. Column 21 is blank. Columns 22-43 are for the first event. Columns 22-29 have the time in seconds with a decimal point in column 28, right justified in columns 30-36 is the occupant node location, and in columns 37-43 is the type of event (1=escape, 2=window, 3=incapacitated, 4=died, 5=end of simulation time). Columns 44-65 are for the second event if one occurred. Columns 44-51 have the time in seconds with a decimal point in column 50, right justified in columns 52-58 is the occupant node location, and in columns 59-65 is the type of event. Columns 66-87 are for the third event if one occurred. Columns 66-73 have the time in seconds with a decimal point in column 72, right justified in columns 74-80 is the occupant node location, and in columns 81-87 is the type of event. The next three lines are the levels of the tenability measures for incapacitation, death and the final simulation time.

3.11 The TIME File

The TIME file contains the delay time in seconds for each occupant type to open a window once they arrive at a window and the time in seconds it is assumed to take for help to arrive after they are called out.

Line 1 of the file corresponds to the delay time for a type 11 or 13 occupant, line 2 to a type 21 or 23 occupant, line 3 to a 31 or 33, line 4 to a type 41 or 43 occupant, line 5 to a type 51 or 53 occupant, line 6 to a 62 or 63 occupant type and line 7 to a type 74 occupant. The corresponding time in seconds are 20, 40, 20, 60, 999999999 (infinity), 999999999, and 40. The eighth line represents the time until help arrives after the first occupant escapes. It is assumed to be 600 seconds.

3.12 The Household Frequency File

The Household Frequency file contains the household count of each occupant set for day, evening and night time. These counts are used in determining the total number of deaths per fire per scenario.

Each line of the file contains a time of day indicator (0=day or evening, 1=night), the types of the occupants in the set, and the number of households having that occupant composition during the day, evening and night time. The time of day indicator is in column 1, the occupant types in the set are in columns 2-11 and the household counts are right justified in columns 12-21, 22-31, 32-41. The occupant sets appear in the same order as they do in the corresponding Occupant Set file.

3.13 The SUMMARY Tables

The SUMMARY Tables summarize the TENABRSK output files. There are 3 sets of six tables. Table 1 is the number of deaths per fire per scenario, Table 2 is the number of deaths per fire by cause of death. Table 3 is the number of deaths per fire per scenario by occupant type. Table 4 is the number of occupants going to windows per fire per scenario by occupant type. Table 5 is a frequency count of the number of people who attempt to escape through a window by household size and Table 6 is a frequency count of the number of occupant deaths per fire per scenario by household size. The three sets of tables differ in the way in which people who attempt to escape out a window are treated and whether or not rescuers can arrive. In Summary set 1, window people are considered to have escaped if they are "alive" after a specified number of seconds after arriving at the window. This specified time is the assumed time it would take to open the window. In Summary set 1, no rescuers come. In Summary set 2 all window people are considered to escape once they reach a window and no rescuers come. Summary set 3 is like set 1, except rescuers can come. Occupants who are alive in the building 10 minutes after the first person escapes are considered to have been rescued and will not die.

PRINTSUM reads a set of summary tables and writes them into a readable form.
STATCOMP reads tables 1 and 2 of a set to produce its two reports.

3.14 The Statistics File

The Statistics File contains the data on the probabilities and number of deaths for each of a collection of scenarios. The file STATS.DAT contains fire incident statistics for scenarios defined by the room of origin, whether a flaming or smoldering fire, the extent of spread, and the type of fire growth and time of day (day, evening or night). The first line indicates the number of fires and a dividing factor. After the first line, each line of the file corresponds to a scenario and contains 3 probabilities and 3 fire death numbers for day, evening and night time respectively. At the end of each line is the "scenario" name.

3.15 The AVL File

The AVL file is a master list of the scenarios run using a particular occupant set, EXITRISK Configuration file, Tenability Limits file, Household Frequency file, Time file, and product number. Along with the scenario names appears the group to which that scenario belongs and the record number for that scenario in the first summary table. The first record of this file indicates how many scenarios are in the file. Each record thereafter, gives the scenario name in columns 1-7, the group number right justified in columns 9-10, and the record numbers for the first summary table and the statistics file right justified in columns 11-17 and columns 18-24, respectively.

3.16 The Probability File

The Probability file provides STATCOMP with estimated probabilities for conditions not considered in the data of the statistics file. For the residential cases, three probabilities must be provided. The first is the probability that there is a working smoke detector present, the second is the probability of a one-story house (ranch house), and the third is the probability that certain doors are closed.

4. Automating the Process, AUTOMATE

Because of the potentially large number of scenarios involved in the Fire Risk Assessment Method, it is desirable to automate the process of running all the cases. Automation also reduces the chance for errors.

AUTOMATE is a program which sets up an automation process for running scenarios through EXITRISK, TENABRSK, and SUMMARY. It requires a minimal set of information from the user. Automate creates an instruction file for each scenario and a terminal command file. The terminal command file is the list of commands which the user would have had to enter in order to run each scenario through EXITRISK, TENABRSK, and

SUMMARY. The advantage of the terminal command file is that once it is submitted, the user is free to do other work.

4.1 AUTOMATE Source Files

There is only a single source file composing AUTOMATE which is AUTOMATE.FTN.

4.2 System Dependencies

There is one system dependency in AUTOMATE. Like the other programs, this program opens the screen, 'C:'. The appropriate device name should replace the 'C:'.

AUTOMATE is dependent upon the scenario/file naming convention that was selected. For Case 1, the scenario/filename convention has the form $n_1n_2n_3n_4n_5n_6$ where n_1 represents the type of building (R for ranch or T for two-story detached house), n_2 represents the room of fire origin (Bedroom, Living room, Kitchen, Dining Room, Garage), n_3 , whether the fire is flaming or smoldering (F or S), n_4 , the extent of spread (1-8), n_5 , whether the doors are opened or closed (O or C), and n_6 , the type of fire growth (SL, SM, ML, MF, MH, UF). From the scenario name, the AUTOMATE program can select the appropriate building and occupant set file. If a different naming convention is used, AUTOMATE must be modified accordingly.

AUTOMATE also uses the file naming convention that the Occupant Set file will have the name RANCH k_1 or TWOSTOR k_1 , the EXITRISK Configuration File will be name EXITT k_2 , the Tenability Limits file will be named CRIT k_3 , the Household Count file will be named HOUSE k_4 , and that the Times file will be name TIMES k_5 , where k_1 , k_2 , k_3 , k_4 , and k_5 are 1-digit in length and specified in the AUTOMATE.DAT file.

4.3 Required Input Files

AUTOMATE requires one file called AUTOMATE.DAT. This file contains scenario information. On the first line is a character string of up to 8 characters. Every line thereafter, corresponds to a particular scenario case. Each scenario case line contains in column 1, the number of FAST dump files for that particular scenario. In columns 3-9 is the scenario name. Column 11 is the product number. In columns 13-17 are the file case indicators (the k_1 , k_2 , k_3 , k_4 , and k_5 mentioned above) where the first position corresponds to the occupant set file, the second, to the EXITRISK Configuration file, the third to the tenability limits file, the fourth to the household count file, and the fifth to the time file. Right justified in columns 19-24 is the group ID to which the scenario belongs and the extent of spread indicators of scenarios sharing the same set of FAST dump files. A blank must separate the group ID from the extent of spread indicators. The difference between some

scenarios is only in the length of the simulation time. This allowed a savings of time and disk space. If there are no related scenarios, the line is left blank after the group ID is given.

4.4 AUTOMATE Output Files

AUTOMATE produces a terminal command file and an Instruction file for each scenario case. The Instruction file was discussed in section 3.4. The terminal command file is the list of commands necessary to process each scenario case through EXITRISK, TENABRSK, and SUMMARY. The terminal command file produced is specific to the Concurrent and must be modified appropriately for other systems. The first line is the SIGNON or log in line. The second through fourth lines set up a log file; a file which is written to instead of the screen (the process is run in background). The fifth line contains a command, RISKV18, followed by an Instruction file name. The command RISKV18 renames the Instruction file name to FILENAME (EXITRISK, TENABRSK, and SUMMARY expect the Instructions file to be named FILENAME on the Concurrent system), runs EXITRISK, TENABRSK and SUMMARY and then renames FILENAME to its previous name.

4.5 Data flow diagram for AUTOMATE

To set up a first product "base" case, the user must set up the Building files, the Occupant Set files, the EXITRISK Configuration file, the Tenability Limits file, the FAST input files and if applicable, the Household Frequency file, the Time file, and the Statistics file. The FAST dump files are then created. The user then creates the AUTOMATE Input file. AUTOMATE is executed and the resulting terminal command file is run. After running all the cases, the user can execute PRINTSUM and STATCOMP. The STATCOMP output can be studied to see how well the predicted death counts compare with the actual death counts.

If the user is not satisfied with "base" case results, he may create additional EXITRISK Configuration files or Tenability Limits files to try to obtain better estimates of the death counts. The above process would be repeated using the new EXITRISK Configuration or Tenability Limits file. The new output would be examined to see if a better fit was obtained.

After the user is satisfied that the process is producing reasonable estimates for the number of deaths, he can set up another product. This is done by creating new FAST input files and dump files corresponding to the properties of the new product, setting up a new AUTOMATE input file and rerunning all the cases using the Tenability Limits and EXITRISK configuration files that gave the best death number estimates in the base case. The two products can then be compared by examining the expected number of deaths for each.

5. Example Cases

The following two example cases are similar to cases 2 and 4 discussed in the earlier reports [3], [5].

5.1 Residential Fire Case

The first example is for a piece of flaming furniture in a ranch house. In preparing to process this case, several files had to be created in advance. They are the Occupant Set files, the Building files, the EXITRISK Configuration file, the Household Frequency file, the Statistics file, the Tenability Limits file, the Time file, and the Probability file. These files would remain fixed for a given set of scenarios for a given product. For each fire scenario, a FAST input file would have to be created. Then, to run all the scenario cases an AUTOMATE input file would be created. These files are shown in full or in part below with comments. Some of the actual files are in Appendix A.

5.1.1 The FAST Input File: RBF7OSL1.DAT

Title and version number

```
VERSN  18      RANCH,BR,FLAMING FURNITURE - BUILD UP TO FLASHOVER
```

Time specification - in terms of FAST_in, this is the overview

```
TIMES    760  100  20   0   0
TAMB    300. 101300.    0.
EAMB    300. 101300.    0.
```

Specify the compartment structure

```
HI/F  0.0  0.0  0.0  0.0  0.0  0.0  0.0
WIDTH  3.60  3.60  4.50  2.70  5.50  3.40  3.80
DEPTH  3.80  3.00  8.10  3.80  1.20  3.00  2.70
HEIGH  2.40  2.40  2.40  2.40  2.40  2.4  2.4
```

Vents to the outside, and the opening/closing parameters

```
HVENT  1  5  1  0.90  2.10  0.00
HVENT  1  8  1  0.05  2.00  0.00  0.00
HVENT  2  5  1  0.90  2.10  0.00
HVENT  2  8  1  0.05  2.00  0.0  0.0
HVENT  3  4  1  0.90  2.10  0.00
HVENT  3  5  1  0.90  2.10  0.00
HVENT  3  8  1  0.05  2.00  0.0  0.0
HVENT  4  5  1  0.90  2.10  0.00
HVENT  4  8  1  0.05  2.00  0.0  0.0
```

```
HVENT 6 5 1 0.90 2.10 0.0
HVENT 6 8 1 0.05 2.00 0.0 0.0
HVENT 7 5 1 0.90 2.10 0.0
HVENT 7 8 1 0.05 2.00 0.0 0.0
```

Thermophysical properties of the boundaries, in this case, a ceiling, wall and floor

```
CEILI GYPSUM GYPSUM GYPSUM GYPSUM GYPSUM GYPSUM
WALLS GYPSUM GYPSUM GYPSUM GYPSUM GYPSUM GYPSUM
FLOOR REDOAK REDOAK REDOAK REDOAK REDOAK REDOAK
```

Specify the fire

```
CHEMI 16. 0. 2.0 14000000. 500.
LFBO 1
LFBT 2
LFPOS 1
LFMAX 15
FTIME 60 60 60 60 23 27 30 60 60 60 60 60 60 60 20
FMASS 0. .00075 .003 .0067 .012 .014 .019 .019 .025 .036 .053 .069 .056 .05
FHIGH .25 .25 .25 .25 .25 .25 .25 .25 .25 .25 .25 .25 .25 .25
FAREA .03 .03 .03 .6 .8 1.0 1.5 3. 3. 3. 3. 3. 3. 3.
HCN .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01 .01
CT 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.
HCR .08 .08 .08 .08 .08 .08 .08 .08 .08 .08 .08 .08 .08 .08
CO .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03 .03
OD .02 .02 .02 .02 .02 .02 .02 .02 .02 .02 .02 .02 .02 .02
```

specify the name of the file for saving time histories

```
DUMPR RBF7OSL1.DMP
```

5.1.2 The Building File for Scenario RBF7OSL1: RANCHO.BLD

The associated FAST dump file was run with 7 rooms and EXITRISK is run with 20 nodes.

```
7 20
```

The mapping between EXITRISK nodes and FAST rooms is that nodes 1, 8 and 20 are in room 1 of FAST, node 2 is in room 2 of FAST, node 3 is in room 6 of FAST, nodes 4, 17, 18 and 19 are in room 3 of FAST, node 5 is in room 4 of FAST, node 6 is in room 7 of FAST, nodes 7, 15, and 16 are in room 5 of FAST, nodes 9 and 10 are exit doors and nodes 11, 12, 13, and 14 are windows. The mapping between EXITRISK nodes and EXITRISK rooms is as follows: nodes 1, 12 and 20 are in EXITRISK room 1, nodes 2 and 13 are in EXITRISK room 2, nodes 3 and 14 are in EXITRISK room 3, nodes 4, 9, 10, 17, 18 and 19 are in EXITRISK room 4, nodes 5 and 11 are in EXITRISK room 5, node 6 is in EXITRISK room 6, nodes 7, 15 and 16 are in EXITRISK room 7 and node 8 is in EXITRISK room 8.

```
1 2 6 3 4 7 5 1 8 8 9 9 9 5 5 3 3 3 1
```

1 2 3 4 5 6 7 8 4 4 5 1 2 3 7 7 4 4 4 1

All nodes have an associated room height of 2.4 meters.

2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4 2.4

All nodes have an associated floor elevation of 0 meters.

0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

The noise level of each room of the building is 35 decibels.

35 35 35 35 35 35 35 35 35 35 35 35 35 35 35 35 35 35 35 35

There is one smoke detector at node 7 which will sound at a time determined by the EXITRISK program. The loudness of the alarm at nodes 7, 15, and 16 will be 95 decibels and at nodes 1-6, 8-14, and 17-20 will be 83 decibels.

1
-1.
7
83 83 83 83 83 83 95 83 83 83 83 83 83 83 95 95 83 83 83 83

The first line of this section indicates that there are 26 edges. The next 26 lines list the pairs of adjacent nodes and their corresponding distances. The first edge, given by 1 12 1.83, indicates that the distance between nodes 1 and 12 is 1.83 meters. The second line, 1 15 3.41, indicates the distance between nodes 1 and 15 is 3.41 meters. The remaining edges are interpreted in a similar manner.

26
1 12 1.83
1 15 3.41
1 20 1.89
2 13 1.52
2 15 2.71
3 7 2.13
3 14 1.52
4 9 3.13
4 18 1.47
4 19 2.38
5 11 2.13
5 16 2.74
5 17 3.35
6 7 2.51
7 15 2.06
7 16 2.44
8 20 1.68
9 19 3.69

```
10 17 1.50
10 18 4.27
12 20 1.57
15 20 4.27
16 19 1.37
17 18 2.05
17 19 4.29
18 19 3.30
```

5.1.3 The Occupant Set File - RANCH0.OCC

Because the occupant set file contains 440 occupant sets we only show 2 sets here. These are the first and last occupant sets in RANCH0.OCC.

```
11000000000 1
11 21 0 4 0 1 0.0 1.3
11410000001 2
11 21 0 4 0 1 0.0 1.3
41 7 0 4 0 110.0 1.0
```

The first set consists of 1 occupant, a type 11, and there is no smoke detector. The occupant is of type 11 (see Table 16 of Case Study 1), is aged 21, female, located at node 4, able to egress on own, is awake, has no sleep penalty and has a travel speed of 1.3 m/s. The next set consists of 2 occupants, types 11 and 41, and there is a working smoke detector. The first occupant is a type 11, aged 21, female, located at node 4, able to egress on own, is awake, has no sleep penalty and has a travel speed of 1.3 m/s. The second occupant is a type 41, aged 7, female, located at node 4, able to egress on own, is awake, has no sleeping penalty, and travels at 1.0 m/s.

5.1.4 The Tenability Limits File: CRITV.RSK

The incapacitation limits for FED, TEMP, CT, FLUX, FEDP, FEDCO, Conv. Heat, O2

```
9999.0 100.0 90.0 99999. 99999. 99999. 99999. 99999.
```

The lethality limits for FED, TEMP, CT, FLUX, FEDP, FEDCO, Conv. Heat, O2

```
9999.0 100.0 90.0 99999. 99999. 99999. 99999. 99999.
```

Critical temperature and upper and lower bounds for interface height

```
50.0 1.0 1.5
```

5.1.5 The EXITRISK Configuration file: EXITT0.FCG

.9 .7

5.1.6 The Household Count File: HOUSE0.CNT

Here are the first and last occupant set counts in HOUSE0.CNT.

| | | | |
|--------------|-------|-------|-----|
| 01100000000N | 38077 | 13216 | 0 |
| 11333434374Y | 0 | 0 | 159 |

5.1.7 The Times File: TIMES0.SEC

A type 1 person takes 20 seconds to open and get out a window, a type 2 person takes, 40, a type 3 takes 20, a type 4 takes 60, and type 5 or 6 cannot open the window (999999 is 'infinity'), and a type 7 takes 40 seconds. Once help is summoned it takes 600 seconds (10 minutes) for help to arrive.

```

20
40
20
60
9999999999
9999999999
40
600

```

5.1.8 The Statistics File: STATS0.DAT

sample lines 1,2,42,481

line 1 is total number of fires, 2044039, and a scale factor of 100.

```
2044039. 100.
```

Columns 1, 2, and 3 are the probability of fire for day, evening and night.

Columns 4, 5, and 6 are the number of deaths per fire for day, evening and night.

Column 7 is the scenario class

(room of origin, flaming or smoldering, extent of spread and fire growth)

| | | | | | | |
|----------|---------|----------|---------|---------|---------|-------|
| 0.00000 | 0.00000 | 0.44000 | 0.86640 | 0.46180 | 0.27330 | BF1FL |
| 8.10000 | 2.07000 | 3.57000 | 0.27560 | 0.10220 | 0.11740 | BF7SL |
| 11.86000 | 0.00000 | 37.98000 | 0.00000 | 0.00000 | 0.00000 | LS8SL |

5.1.9 The Probability File: PROBAB.DAT

The probability of a working detector present is .19; the probability of a ranch type house is .70 (implies probability of a two-story detached house is .3), probability of doors being closed is .5.

.19 .7 .5

5.1.10 The AUTOMATE Input file: AUTOMATE.DAT

The Terminal Command File will be named TESTCASE.BAT. Only 1 scenario case, RBF7OSL for product 1, will be run using RBF7OSL1.DMP, EXITT0.FCG, RANCHO.OCC, RANCHO.BLD, CRITV.RSK, TIMES0.SEC and HOUSE0.CNT. This case is assigned to be in group 1. No other scenarios share RBF7OSL1.DMP.

```
TESTCASE
1 RBF7OSL 1 00V00 1
```

Having set up all required files FAST was executed using the input file RBF7OSL1.DAT to create RBF7OSL1.DMP. AUTOMATE was then executed which created the Instruction files RBF7OSL1.001 and the Terminal Command file TESTCASE.BAT. TESTCASE.BAT was then executed.

5.1.11 The Instruction File: RBF7OSL1.001

List of files, related scenarios and indices to be used and/or created by EXITRISK, TENABRSK and SUMMARY.

```
6
RBF7OSL1.DMP
RBF7OSL1.D00
RBF7OSL1.V00
RANCHO.BLD
RANCHO.OCC
CRITV.RSK
EXITT0.FCG
1
99999.00 RBF7OSL1 V0000
HOUSE0.CNT
TIMES0.SEC
1 41
V000011.TB1
V000011.TB2
V000011.TB3
V000011.TB4
V000011.TB5
V000011.TB6
V00001.AVL
V000012.TB1
```

V000012.TB2
V000012.TB3
V000012.TB4
V000012.TB5
V000012.TB6
V00001.AVL
V000013.TB1
V000013.TB2
V000013.TB3
V000013.TB4
V000013.TB5
V000013.TB6
V00001.AVL

5.1.12 The Terminal Command file created by AUTOMATE: TESTCASE.BAT

Sign onto the system and set up log file, then run each scenario case.

```
SI TESTCASE,100,XXX
XDE TESTCASE.LOG
AL TESTCASE.LOG,IN,80
LOG TESTCASE.LOG
RISKV18 RBF7OSL1.001
SO
```

Copy of RISKV18.CSS which executes EXITRISK, TENABRSK, and SUMMARY.

```
RENAME @1,FILENAME
RUN EXITRISK
RUN TENABRSK
RUN SUMMARY
RENAME FILENAME,@1
$EXIT
```

5.1.13 Occupant Escape Route File created by EXITRISK: RBF7OSL1.D00

Only the first 15 and last 30 lines are displayed below.

```
1800 12/05/88 05/03/90
RBF7OSL1.DMP
RBF7OSL1.D00
RANCHO.BLD
$RANCHO.OCC
20
  1    2    6    3    4
  7    5    1    8    8
  9    9    9    9    5
  5    3    3    3    1
1100000000 0    1
  1    4    0    0.00
  1   19  1408  0.00
  1    9  1460  0.00
  0    0    0    0.00
1333434374 1    5
  1    1    0    0.00
```

| | | | |
|---|----|------|------|
| 2 | 2 | 0 | 0.00 |
| 3 | 2 | 0 | 0.00 |
| 4 | 3 | 0 | 0.00 |
| 5 | 4 | 0 | 0.00 |
| 1 | 15 | 860 | 0.00 |
| 1 | 7 | 872 | 0.00 |
| 1 | 16 | 887 | 0.00 |
| 1 | 19 | 895 | 0.00 |
| 1 | 4 | 909 | 0.00 |
| 1 | 9 | 952 | 0.00 |
| 2 | 15 | 951 | 0.00 |
| 3 | 15 | 957 | 0.00 |
| 4 | 7 | 951 | 0.00 |
| 2 | 1 | 977 | 0.00 |
| 3 | 7 | 978 | 0.00 |
| 4 | 16 | 976 | 0.00 |
| 4 | 19 | 989 | 0.00 |
| 5 | 9 | 983 | 0.00 |
| 3 | 16 | 1002 | 0.00 |
| 3 | 19 | 1016 | 0.00 |
| 4 | 9 | 1018 | 0.00 |
| 2 | 15 | 1027 | 0.00 |
| 2 | 7 | 1039 | 0.00 |
| 3 | 9 | 1044 | 0.00 |
| 2 | 16 | 1054 | 0.00 |
| 2 | 19 | 1062 | 0.00 |
| 2 | 9 | 1084 | 0.00 |
| 0 | 0 | 0 | 0.00 |

5.1.14 TENABRSK Output: RBF7OSL1.V00

Only the first 15 and last 21 lines are shown.

```

FAST Version: 18.3
TENAB Version: 18.0 - Creation Date: 12/05/88 - Run Date: 05/03/90
RBF7OSL1.DMP
RBF7OSL1.D00
RBF7OSL1.V00
CRITV.RSK
0.9999000E+04 0.1000000E+03 0.9000000E+02 0.9999900E+05 0.9999900E+05 0.9999900E+05 0.9999900E+05
0.9999900E+05
0.9999000E+04 0.1000000E+03 0.9000000E+02 0.9999900E+05 0.9999900E+05 0.9999900E+05 0.9999900E+05
0.9999900E+05
1
99998
1100000000 0 1 .146000000E+03
11 000000000000000001 146.0 9 3
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
0.0000000E+00
1333434374 1 5 .952000000E+02
13 000000000000000001 95.2 9 3
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
0.0000000E+00

```

```

33 00000000000000001 108.4 9 3
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
0.0000000E+00
43 00000000000000001 104.4 9 3
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
0.0000000E+00
43 00000000000000001 101.8 9 3
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
0.0000000E+00
74 00000000000000001 98.3 9 3
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
-0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01 -0.1000000E+01
-0.1000000E+01
0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
0.0000000E+00

```

5.1.15 The AVL File created by SUMMARY: V00001.AVL

```

2
RBF70SL 1 1 41

```

5.1.16 The STATCOMP Output files: V0000101.A2 and V0000101.B2

First output: V0000101.A2

USING TABLE V000012.TB1 WHICH WAS CREATED WITH THE
FOLLOWING FILES

```

THE TENABILITY LIMITS FILE      : CRITV.RSK
THE OCCUPANT SET FILES          : ----0.OCC
THE EXITRISK CONFIGURATION FILE : EXITT0.FCG
THE HOUSEHOLD COUNT FILE       : HOUSE0.CNT
THE TIME FILE                   : TIMES0.SEC
THE PRODUCT NUMBER              : 1

```

COUNTING METHOD USED: NO RESCUERS COME - WINDOW PEOPLE ESCAPE

```

FED - CO2      FED - O2      FED  TEMPERATURE      CT      FLUX  FED - PURSER CONVECT. HEAT
INCAP LEVELS: 0.9999000E+04 0.1000000E+03 0.9000000E+02 0.9999900E+05 0.9999900E+05 0.9999900E+05
0.9999900E+05 0.9999900E+05

```

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LETHAL LEVELS: 0.9999000E+04 0.1000000E+03 0.9000000E+02 0.9999900E+05 0.9999900E+05 0.9999900E+05
0.9999900E+05 0.9999900E+05

DAY CASES GROUP - 1
PROB(SMOKE DETECTOR) = 0.19
PROB(RANCH HOUSE) = 0.70
PROB(2-STORY HOUSE) = 0.30
PROB(CLOSED DOORS) = 0.50

| SCENARIO | PROBABILITY
X1000 | DEATHS
PER 100
FIRES
ACTUAL | TOTAL
DEATHS
ACTUAL | DEATHS
PER 100
FIRES
COMPUTED | TOTAL
DEATHS
COMPUTED |
|----------|----------------------|--------------------------------------|---------------------------|--|-----------------------------|
| BF7SL* | 0.27560 | 8.10000 | 9.12606 | 0.95550 | 1.07654 |
| TOTAL* | 0.27560 | | 9.12606 | | 1.07654 |
| TOTAL | 0.27560 | | 9.12606 | | 1.07654 |
| FLAME* | 0.27560 | | 9.12606 | | 1.07654 |
| FLAME | 0.27560 | | 9.12606 | | 1.07654 |
| SMOLD* | 0.00000 | | 0.00000 | | 0.00000 |
| SMOLD | 0.00000 | | 0.00000 | | 0.00000 |

Second output V0000101.B2

USING TABLE V000012.TB2 WHICH WAS CREATED WITH THE
FOLLOWING FILES

THE TENABILITY LIMITS FILE : CRITV.RSK
THE OCCUPANT SET FILES : -----0.OCC
THE EXITRISK CONFIGURATION FILE : EXITTO.FCG
THE HOUSEHOLD COUNT FILE : HOUSE0.CNT
THE TIME FILE : TIMES0.SEC
THE PRODUCT NUMBER : 1

COUNTING METHOD USED: NO RESCUERS COME - WINDOW PEOPLE ESCAPE

| | FED | TEMPERATURE | CT | FLUX | FED - PURSER CONV. HEAT | FED - CO2 | FED |
|----------------|-------------|-------------|-------------|-------------|-------------------------|-------------|-------------|
| - 02 | | | | | | | |
| INCAP LEVELS: | 0.99990E+04 | 0.10000E+03 | 0.90000E+02 | 0.99999E+05 | 0.99999E+05 | 0.99999E+05 | 0.99999E+05 |
| LETHAL LEVELS: | 0.99990E+04 | 0.10000E+03 | 0.90000E+02 | 0.99999E+05 | 0.99999E+05 | 0.99999E+05 | 0.99999E+05 |

DAY CASES GROUP - 1
PROB(SMOKE DETECTOR) = 0.19
PROB(RANCH HOUSE) = 0.70
PROB(2-STORY HOUSE) = 0.30
PROB(CLOSED DOORS) = 0.50

| SCENARIO | FED | TEMPERATURE | CT | FLUX | FED - PURSER | CONV. HEAT | FED - CO2 |
|----------|---------|-------------|---------|---------|--------------|------------|-----------|
| BF7SL* | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 100.00000 | 0.00000 | 0.00000 |
| 0.00000 | | | | | | | |

| | | | | | | | |
|---------|---------|---------|---------|---------|-----------|---------|---------|
| TOTAL* | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 100.00000 | 0.00000 | 0.00000 |
| 0.00000 | | | | | | | |
| TOTAL | | | | | | | |
| FLAME* | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 100.00000 | 0.00000 | 0.00000 |
| 0.00000 | | | | | | | |
| FLAME | | | | | | | |
| SMOLD* | | | | | | | |
| SMOLD | | | | | | | |

5.1.16 The PRINTSUM output file: V0000121.G1

USING TABLE V000012.TB1 WHICH WAS CREATED WITH THE FOLLOWING FILES

THE TENABILITY LIMITS FILE : CRITV.RSK
 THE OCCUPANT SET FILES : -----0.OCC
 THE EXITRISK CONFIGURATION FILE : EXITT0.FCG
 THE HOUSEHOLD COUNT FILE : HOUSE0.CNT
 THE TIME FILE : TIMES0.SEC
 THE PRODUCT NUMBER : 1

COUNTING METHOD USED: NO RESCUERS COME - WINDOW PEOPLE ESCAPE

| | FED | TEMPERATURE | CT | FLUX | FED - PURSER CONV. HEAT | FED - CO2 | FED |
|----------------|-------------|-------------|-------------|-------------|-------------------------|-------------|-------------|
| - O2 | | | | | | | |
| INCAP LEVELS: | 0.99990E+04 | 0.10000E+03 | 0.90000E+02 | 0.99999E+05 | 0.99999E+05 | 0.99999E+05 | 0.99999E+05 |
| 0.99999E+05 | | | | | | | |
| LETHAL LEVELS: | 0.99990E+04 | 0.10000E+03 | 0.90000E+02 | 0.99999E+05 | 0.99999E+05 | 0.99999E+05 | 0.99999E+05 |
| 0.99999E+05 | | | | | | | |

DEATHS/FIRE

| SCENARIO | WITH SMOKE DETECTORS | | | WITHOUT SMOKE DETECTORS | | |
|----------|----------------------|---------|--------|-------------------------|---------|--------|
| | DAY | EVENING | NIGHT | DAY | EVENING | NIGHT |
| GROUP 1 | | | | | | |
| RBF7OSL | 0.0273 | 0.0150 | 0.0100 | 0.0273 | 0.0150 | 0.0108 |

5.2 Restaurant Fire Case

The second example case is a wall burning in a single room restaurant.

5.2.1 FAST Input File

The first few sections of this file, the burning wall in the restaurant, is the same as for the previous data file

VERSN 18 SINGLE ROOM - GREASE FIRE - FFM MODEL - ATMI Q
 TIMES 18 2 1 0 0

```
TAMB 300. 101300. 0.
EAMB 300. 101300. 0.
HI/F 0.00
WIDTH 11.50
DEPTH 12.20
HEIGH 2.40
HVENT 1 2 1 0.02 2.00 0.00 0.00
CEILI GYPSUM
WALLS GYPSUM
FLOOR CONCRETE
CHEMI 16. 0. 10.0 18000000. 300.
LFBO 1
```

A type five fire is a furniture fire. A type one fire is an unconstrained gas burner, two is an oxygen limited gas burner, three and four are not implemented but are reserved for pool fires

```
LFBT 5
LFPOS 1
FTIME 10.
CT 1.0 1.0
DUMPR MATQRES2.D21
```

Here we specify the additional data needed to invoke the furniture fire model

```
MOCKP MOCKUP6.DAT
BENCH MATQBNCH.DAT
CONEF MATQ30.DAT
CONEF MATQ50.DAT
```

5.2.2 The Instruction File

For this case only MATQRES2.D11, MATQ.DDD, MATQRS12.J00, and CRITJ.RSK are required

All other files listed below are not referenced for this case.

```
6
MATQRES2.D11
MATQ.DDD
MATQRS12.J00
RANCHO.BLD
RANCHO.OCC
CRITJ.RSK
EXITTO.FCG
1
99999.0000 MATQRS12 J00
HOUSE0.CNT
TIMES0.SEC
1 1
J000011.TB1
J000011.TB2
J000011.TB3
J000011.TB4
J000011.TB5
J000011.TB6
J00001.AVL
J000012.TB1
J000012.TB2
```

J000012.TB3
 J000012.TB4
 J000012.TB5
 J000012.TB6
 J00001.AVL
 J000013.TB1
 J000013.TB2
 J000013.TB3
 J000013.TB4
 J000013.TB5
 J000013.TB6
 J00001.AVL

5.2.3 The Occupant Escape Route File

This file was created by the user. One occupant is in each room for the duration for the simulation

```
1800 12/05/88 05/03/90
blank line
blank line
$
  2
    1      1
1100000000 0    1
    1      1    0    0.00
    0      0    0    0.00
```

5.2.4 The Tenability Limits File: CRITJ.RSK

The incapacitation limits for FED, TEMP, CT, FLUX, FEDP, FEDCO, Conv. Heat, O2

```
9999.0  99999.  90.0  99999.  1.  99999.  99999.  99999.
```

The lethality limits for FED, TEMP, CT, FLUX, FEDP, FEDCO, Conv. Heat, O2

```
9999.0  99999.  90.0  99999.  1.  99999.  99999.  99999.
```

Critical temperature and upper and lower bounds for interface height

```
50.0 1.0 1.5
```

5.2.5 The TENABRSK Output File: MATQRS12.J00

At 149 seconds a person in room 1 becomes incapacitated due to Purser's FED

```
FAST Version: 18.3
TENAB Version: 18.0 - Creation Date: 12/05/88 - Run Date: 05/17/90
MATQRES2.D11
MATQ.DDD
MATQRS12.J00
CRITJ.RSK
0.9999000E+04 0.9999000E+05 0.9000000E+02 0.9999000E+05 0.1000000E+01 0.9999000E+05 0.9999000E+05
0.9999000E+05
0.9999000E+04 0.9999000E+05 0.9000000E+02 0.9999000E+05 0.1000000E+01 0.9999000E+05 0.9999000E+05
0.9999000E+05
1
99998
1100000000 0 1 .999998800E+05
11 00001000000010002 149.0 1 1 149.0 1 2
0.5033703E-01 0.2089041E+03 0.0000000E+00 0.2998755E+01 0.1153319E+01 0.5195682E+00 0.4058244E+01
0.5033703E-01
0.5033703E-01 0.2089041E+03 0.0000000E+00 0.2998755E+01 0.1153319E+01 0.5195682E+00 0.4058244E+01
0.5033703E-01
0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
0.0000000E+00
```

Table 1. List of Files Provided on Tape

| File name | File type or purpose |
|--------------|---|
| FAST.FTN | fire model |
| FFM.FTN | furniture fire model |
| FASTPLOT.FTN | source file for FASTPLOT plotting routine |
| DEVICE.FTN | device independent graphics interface |
| XYZPLOT.FTN | 3d perspective plot of burning objects |
| HSET.FTN | convert Hershey stroke file to packed array |
| HSIZE.FTN | show characters |
| NGROUPH.FTN | regroup Hershey packed array into devfont.nnn |
| NHHSIZE.FTN | view a character from the devfont.nnn files |
| FASTPLOT.FTN | post processor of FAST dump file |
| ALPHA.DAT | Hershey stroke character file |
| ALPHA.PAK | packed form of character file produced by hset.ftn |
| DEVFONT.004 | #4 font file |
| MATQ30.DAT | cone calorimeter data for material Q for 30 kW/m ² |
| MATQ50.DAT | " " " " " " 50 " |
| MATQBNCH.DAT | flame spread (LIFT) data for material Q |
| MATQRES2.DAT | FAST data file for the restaurant case |
| THERMAL.DAT | thermophysical properties |
| MOCKUP6.DAT | geometry file for the wall for the restaurant case |
| FFM.RUN | CSS file to run example 2 |
| EXITRISK.FTN | source file for EXITRISK program (evacuation model) |
| TENABRSK.FTN | Source file for TENABRSK program (tenability program) |
| NTRFACEX.FTN | source file for EXITRISK |
| NTRFACTE.FTN | source file for TENABRSK |
| FASTREAD.FTN | source file for EXITRISK and TENABRSK |
| SUMMARY.FTN | source file for SUMMARY program |
| PRINTSUM.FTN | source file for PRINTSUM program |
| STATCOMP.FTN | source file for STATCOMP program |
| CRAVL.FTN | source file for SUMMARY, PRINTSUM, and STATCOMP |
| AUTOMATE.FTN | source file for AUTOMATE program |
| RBF7OSL1.DAT | data file for example 1 - FAST Input file |
| RBF7OSL1.DMP | data file for example 1 - FAST Dump file |
| RISKV18.CSS | CSS file for example 1 |
| AUTOMATE.DAT | data file for example 1, an AUTOMATE Input file |
| RBF7OSL1.001 | data file for example 1, an Instruction file |
| TESTCASE.BAT | Terminal Command file for example 1 |
| EXIT70.FCG | data file for example 1 - EXITRISK Configuration file |
| RANCHO.OCC | data file for example 1 - Occupant Set file |
| RANCHO.BLD | data file for example 1 - Building file |
| RBF7OSL1.D00 | Occupant Escape Route file for example 1 |
| CRITV.RSK | data file for example 1 - Tenability Limits file |
| RBF7OSL1.V00 | Tenability Output file for example 1 |
| TIMES0.SEC | data file for example 1 - Time file |
| HOUSE0.CNT | data file for example 1 - Household Frequency file |
| V00001.AVL | AVL file for example 1 |
| V000011.TB1 | data file for example 1 - SUMMARY Table Set 1 |
| V000011.TB2 | " " " |
| V000011.TB3 | " " " |
| V000011.TB4 | " " " |
| V000011.TB5 | " " " |
| V000011.TB6 | " " " |
| V000012.TB1 | data file for example 1 - SUMMARY Table Set 2 |
| V000012.TB2 | " " " |
| V000012.TB3 | " " " |
| V000012.TB4 | " " " |
| V000012.TB5 | " " " |
| V000012.TB6 | " " " |
| V000013.TB1 | data file for example 1 - SUMMARY Table Set 3 |
| V000013.TB2 | " " " |

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| | | | |
|--------------|---|---|---|
| V000013.TB3 | " | " | " |
| V000013.TB4 | " | " | " |
| V000013.TB5 | " | " | " |
| V000013.TB6 | " | " | " |
| V0000121.G01 | data file for example 1 - PRINTSUM - from SUMMARY TABLE Set 2 | | |
| V0000122.G01 | " | " | " |
| V0000123.G01 | " | " | " |
| V0000124.G01 | " | " | " |
| V0000125.G01 | " | " | " |
| V0000126.G01 | " | " | " |
| PROBAB.DAT | data file for example 1 - Probability file | | |
| STATS.DAT | data file for example 1 - Statistics file | | |
| V0000101.A2 | data file for example 1 - STATCOMP output | | |
| V0000101.B2 | data file for example 1 - STATCOMP output | | |
| MATQRES2.D11 | data file for example 2 - FAST dump file | | |
| MATQ.DDD | data file for example 2 - Occupant Escape Route file | | |
| CRITJ.RSK | data file for example 2 - Tenability Limits file | | |
| MATQRS12.J00 | data file for example 2 - Tenability Output | | |

Table 2. Summary of Program Information.

| | Description | Source Files | Input Files | Output Files |
|---------------------|---|--|---|---|
| FAST | To calculate the interface height, optical density and toxic gases in the upper and lower layers of each room over time in a burning building | FAST.FTN
DEVICE.FTN
HSETS.DAT
XYZPLOT.FTN | Scenario Description
Thermophysical Properties | FAST dump |
| FASTPLOT
XYZPLOT | Plot data from a dump file | FASTPLOT.FTN | Dump file produced by FAST or FFM | Screen or plotter graph |
| EXITRISK | To determine the occupant locations over time as they egress a burning building | EXITRISK.FTN
NTRFACEX.FTN
FASTREAD.FTN | Instruction
FAST dump
EXITRISK Configuration
Building
Occupant Set | Occupant Escape Route |
| TENABRSK | To calculate the tenability conditions to which an occupant is exposed in a burning building | TENABRSK.FTN
NTRFACTX.FTN
FASTREAD.FTN | Instruction
FAST dump
Occupant Escape Route
Tenability Limits | Tenability Output |
| SUMMARY | To calculate the number of deaths attributed to a given fire scenario | SUMMARY.FTN
CRAVL.FTN | Instruction
Tenability Output
Household Frequency
Time | 3 sets of 6 summary tables |
| PRINTSUM | To print out the tables produced by SUMMARY in a user readable form | PRINTSUM.FTN
CRAVL.FTN | Keyboard input from user
SUMMARY Tables 1-6 of one set

AVL
Tenability Limits | 1 set of summary tables for a particular subset of scenarios |
| STATCOMP | To calculate the number of deaths for a class of fire scenarios to be compared with known statistics | STATCOMP.FTN
CRAVL.FTN | Keyboard input from user
SUMMARY Tables 1 and 2 of one set

AVL file
Tenability Limits
Probability
Statistics | Report on predicted and actual numbers of deaths

Report on percent of deaths due to each tenability measure. |
| AUTOMATE | To produce "instruction" files and a terminal command file for automating the process of running EXITRISK, TENABRSK, and SUMMARY | AUTOMATE.FTN | AUTOMATE input file | Instruction file for each scenario in the AUTOMATE input file

Terminal Command |

Table 3. Type of Dependencies and Source Code Affected.

| Dependencies | Source Files |
|---|---|
| Console Screen Device Name 'C:' | EXITRISK.FTN
TENABRSK.FTN
SUMMARY.FTN
STATCOMP.FTN
PRINTSUM.FTN
AUTOMATE.FTN |
| Unit number attached to Console Screen - SPUNIT=10

SCREEN=10 | EXITRISK.FTN
TENABRSK.FTN
SUMMARY.FTN
STATCOMP.FTN
PRINTSUM.FTN
AUTOMATE.FTN |
| Function DATE(IDATE) where IDATE is an integer array of length 3 and IDATE(1), IDATE(2), and IDATE(3) represent the current year, month, and day. | EXITRISK.FTN
TENABRSK.FTN |
| INFILE='FILENAME' - only needs to be changed if 'FILENAME' is not a valid filename on the system selected to run the code | EXITRISK.FTN
TENABRSK.FTN
SUMMARY.FTN |
| SYSIO call | FASTREAD.FTN
FAST.FTN
FFM.FTN
FASTPLOT.FTN |
| Scenario file naming convention | STATCOMP.FTN
AUTOMATE.FTN |

Table 4. Brief Description of Input and Output Files and Which Programs Use Them.

| File | Description | Created By | Read By |
|-----------------------------|--|------------------|----------------------------------|
| FAST Input File | | | |
| FAST Database File | | | |
| FAST Dump File | | FAST | EXITRISK
TENABRSK |
| Instruction File | List of files and indices associated with EXITRISK, TENABRSK, and SUMMARY | AUTOMATE
User | EXITRISK
TENABRSK
SUMMARY |
| EXITRISK Configuration File | Initial trigger smoke interface height and a doubling stimulus trigger smoke interface height | User | EXITRISK |
| Building File | Information about the layout of the building and smoke detector information | User | EXITRISK |
| Occupant Set File | Information on the characteristics of the occupants in the building | User | EXITRISK |
| Occupant Escape Route File | Information on the locations of the occupants over time as they egress the building | EXITRISK
User | TENABRSK |
| Tenability Limits File | Contains the incapacitation and lethality thresholds for each tenability measure | User | TENABRSK
PRINTSUM
STATCOMP |
| Tenability Output File | Information on each occupants condition at the end of the simulation (incapacitated, dead, or alive) | TENABRSK | SUMMARY |
| Time File | The time allowed for each occupant type to open a window and escape and the time it takes rescuers to arrive once they are called | User | SUMMARY |
| Household Frequency File | The frequency with which each occupant set occurs | User | SUMMARY |
| SUMMARY Tables | A set of 6 tables summarizing the Tenability output in terms of the number of deaths, number of deaths by cause, number of deaths by occupant type, etc. | SUMMARY | STATCOMP
PRINTSUM |
| Statistics File | The probability of and the number of deaths for a given set of fire scenario classes | User | STATCOMP |
| AVL File | List of fire scenarios processed | SUMMARY | SUMMARY
STATCOMP
PRINTSUM |
| Probability File | Probabilities assigned to certain conditions occurring | User | STATCOMP |

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NIST-114A
(REV. 3-90)

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

BIBLIOGRAPHIC DATA SHEET

1. PUBLICATION OR REPORT NUMBER

NISTIR 4401

2. PERFORMING ORGANIZATION REPORT NUMBER

3. PUBLICATION DATE

September 1990

4. TITLE AND SUBTITLE

Fire Risk Assessment Method: Guide to the Risk Methodology Software

5. AUTHOR(S)

C. Lynn Forney and Walter W. Jones

6. PERFORMING ORGANIZATION (IF JOINT OR OTHER THAN NIST, SEE INSTRUCTIONS)

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
GAITHERSBURG, MD 20899

7. CONTRACT/GRANT NUMBER

Internal Report, Final

8. TYPE OF REPORT AND PERIOD COVERED

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (STREET, CITY, STATE, ZIP)

The National Fire Protection Research Foundation
1 Batterymarch Park
Quincy, MA 02269

10. SUPPLEMENTARY NOTES

11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

This guide provides the background on the computer programs used in the Risk Assessment Method. The program modules are tabulated and explained, together with the file requirements for each. Two examples are carried through the process to show the actual use of the programs in performing an assessment of the risk due to unwanted fires.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

compartment fires; fire growth; risk assessment; software development; fire hazard

13. AVAILABILITY

☒

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WASHINGTON, DC 20402.

☒

ORDER FROM NATIONAL TECHNICAL INFORMATION SERVICE (NTIS), SPRINGFIELD, VA 22161.

14. NUMBER OF PRINTED PAGES

55

15. PRICE

A04

ELECTRONIC FORM

